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Suspected Repetition, or Second Outbursts from Radiant Points; and on the Long Duration of Meteor Showers. By W. F. Denning, Esq.

The radiant-points which I have reduced—chiefly from my observations of the paths of 2,690 shooting stars between April 1876 and December 1877, and from the Catalogue of the Italian Meteoric Association (1872), which I have recently been comparing together and with the positions obtained by other observers—appear to prove that many showers have very long duration. In some well-marked cases the period extends over four months at least, which is much greater than that commonly assigned to them; in fact, I believe that, of the showers previously known, not more than three last longer than eight or nine weeks, and certainly none longer than twelve weeks. My own observations and reductions would, however, considerably extend the duration generally, and there appears to be a tendency in many radiants to repeat themselves (or give secondary outbursts), at an interval of about three months after the first display. There is no absolute cessation of action during the intervening lull, though meteors come very sparingly, and seldom in sufficient number to constitute a "shower," on one or two nights. It is true that there are now so many known radiant-points differing in dates, positions, intensities, &c. (and these only approximately ascertained in numerous instances), that it is but fair to expect many accidental coincidences in position such as I have been referring to, and that they are merely different showers coming later from same places. This seems the natural explanation, and it is rendered more probable by the fact that meteor showers make their appearance, as a rule, round about the Earth's apex, and are rarely seen active or well defined far away from it. In fact, these systems are generally confined to a minor part of the heavens, and thus it would be singular indeed if, with so many different showers, we had no instances in which the radiant positions were found to overlap or overlie. There is also this to be said, that absolute accuracy is never attained in this branch of observation, and that a radiant of a feeble system can seldom be relied upon, except in special cases, to within five or seven degrees. Moreover, the idea of these repeating radiants (assuming them to belong to the same parent system), is opposed to the relation of comets and meteors in the simple form we understand it, and cannot easily be accounted for. It seems to me, however, that, notwithstanding all this, the large number of the agreements and their exact nature are strongly suggestive of some connection, and require a different explanation to that indicated above. I have no longer any hesitation in mentioning it as a point deserving special attention from workers in this department. In the present very imperfect state of our knowledge it would be wrong to hastily condemn any observed facts, however improbable and incomprehensible they may at first sight appear.

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The following are a few cases of these radiants which I have selected as samples of many others that might be adduced. The positions are from my own observations or the Italian ones, and a few are included that I reduced from the late Dr. Heis's recently published work, *Resultate der in den* 43 *Jahren* 1833–75, *angestellten Sternschnuppen Beobachtungen* (Munster, 1877), and Zezioli's Catalogue of 8,623 meteors, 1867-70, which had, however, already been partially reduced, the former by Heis himself, and the latter by Schiaparelli. The various radiants determined from these sources are incorporated, and an average taken, but only in cases when they agreed very closely, and unmistakably belonged to identical systems:—

I. *First Display.*					II. *Second Display.*				
Dates.	No. of Positions.	No. of Meteors.	Radiant-point. R.A. °	Decl. °	Radiant-point. R.A. °	Decl. °	No. of Meteors.	No. of Positions.	Dates.
Aug. 6–12	2	61	97	+71	101	+73	27	3	Oct. 2—Dec. 2
Aug. 6—Sept.	4	63	46	+73	43	+73	32*	4	Oct. 28—Nov.
Aug. 6–12	1	21	76	+33	77	+31	17	2	Oct. 2—Nov. 13
Aug. 6–16	3	61	70	+64	69	+66	40	5	Nov.—Dec.
July—Sept.	5	76	62	+48	62	+48	38	5	Oct.—Nov. 13
Aug.—Sept.	5	82	61	+37	61	+36	33	4	Oct.—Dec.
Aug.—Sept.	5	41	44	+24	45	+25	65	4	Oct.—Nov.
Oct. 2—Dec.	4	53	131	+20	132	+20	27	3	Feb.—April
Nov. 22—Dec. 13	2	47	81	+23	83	+22	23*	2	Feb.—Mar. 12
February	1	10	132	+67	134	+67	32*	2	April—May 15

* New showers requiring confirmation.

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I believe the 10 pairs of radiants in this Table are accurately placed; they are supported by a large number of meteors and (with four exceptions) agree with showers seen by former observers. Many other such agreements as are here presented will be found by consulting the radiant-lists of Greg and Herschel, Heis, Schmidt, Schiaparelli and Zezioli, and Tupman. The following are a few additional ones from my own observations:—

	° °	° °	
Mar. 18—May 17	286−13	284−11	July 6—Aug. 16.
Sept.—Nov.	130+47	130+44	Jan. 4–20.
April 21—May	280+58	284+57	July 16—Aug. 16.
Dec. 10—Jan. 20	221+41	220+40	Mar. 14—April.
Aug. 3–16.	31+18	30+16	Oct. 28—Nov. 13.
Nov.—Dec.	173+ 9	175+10	March.
Nov.—Dec.	182+36	181+34	Feb. 20.
Oct. 2	225+52	221+52	Dec. 12—Jan. 20.
April 16–19	267+21	267+20	Aug. 5—Sept. 7.
May 15	304+ 7	306+ 6	Aug. 3–16.

The number might be greatly extended. Thus, there are apparently recurring showers in the months of July and October from 30°+36°, 47°+45°, 9°+34°, 80°+56°, 6°+52°, and in October and January from 105°+50°, 104°+13°, 153°+42°, 120°+15°, 136°+78°, &c.; and it appears certain that a radiant-point agreeing with that of the August *Perseids* is continued from that month to December! An average of 14 positions gives 45°+57° as the centre of it. Now Mr. Greg's general central radiant for the August *Perseids* is at 44°+56°, which accords almost precisely with the preceding one. The November *Perseids* Mr. Greg places at 46°+55°, and the position was well confirmed by Heis at 44°+56° from 48 meteors seen during the first half of the month. Thus it is evident that the August and November *Perseids* have precisely the *same radiant-point.* Not only Heis, but Greg and Herschel, and Schiaparelli and Zezioli saw the shower well defined in November. From my own observations and those made in Italy, the radiant also appears tolerably active during the first half of September, and Captain Tupman saw it accurately at 42°+55° on the morning of September 5, 1870. These later meteors from *Perseus*, seldom have streaks like those of about August 10, and it is very probable that they belong to quite a distinct system. There is no doubt, however, that after the maximum on August 10 there is still a lingering shower from the same centre, and that it reaches its greatest intensity about three months after the first display, which confirms the periods observed in revivals of other showers.

It is a peculiar thing to say that a person may see, by looking towards the eastern sky (at the constellations of *Perseus*, *Auriga*, and *Camelopardalus*) in the evenings of November, many of the same radiants that were visible in the early mornings of August,

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or that the radiants observable in the mornings of November come into play again in the evenings of February, &c.; but that seems a probable conclusion from numerous observations and reductions. Fortunately the question may soon be settled without waiting for further observations. The Catalogues before mentioned contain hosts of well-observed meteor paths from which it will be possible to confirm or disprove these reappearing meteor systems, though the work will entail much labour, and there will be some difficulty in getting at the radiant-points accurately. I would suggest that, if it is undertaken, the meteors for August 1–15 be first examined, and those presumably belonging to radiants *eastwards of Perseus* (say between 50°–110° R.A. and 20°–80° North Decl.) selected. This may be done by a glance at the places of beginning and ending, and in this way the mass of ordinary *Perseids* may be avoided. A series of similar star charts must be used in the projections, and the radiant-points determined from each, then the positions of the nearly accordant showers averaged. Following the same plan for the first half of November, the two results would admit of fair comparison. There would be some showers in November not seen in August and *vice versâ*, but in many instances, I believe, the positions will be identical, or so nearly accordant as errors of observation and reduction will allow. I shall look forward with much satisfaction to the confirmation of a new August shower in *Camelopardalus* at $97^\circ + 71^\circ$, which I found splendidly defined from two independent sources, and it is difficult to understand how Heis missed this radiant (though he saw many of its meteors) during the 43 years that he gave great attention to the meteors of August.

Postscript.

Since writing this paper I have partially reinvestigated the positions on which I chiefly rely as proving these repeating meteor showers, and have been projecting the paths of many hnndreds of shooting stars recorded during the first half of January, with the view to ascertain whether a number of radiants I observed in the mornings of last October recurred again, as they should according to my previous observations. The result of the examination was very satisfactory in each case, and apparently proved in the most palpable and conclusive manner the suspicion I have ventured to mention in this paper, namely, that there is more than one outburst from radiant-points, and two maxima at intervals of about three months, little more or less. I do not mean to say that they can possibly represent the same parent systems, and that the two displays are simply manifestations of one stream, because that is incredible and unaccountable from existing theories. The subject is very wide and difficult, requiring yet much further assiduous work before we may hope to unravel the vast and complicated network of meteor streams which the Earth annually encounters.